U. S. INSPECTION TEAM REPORT

OF

VISIT TO ISRAELI ATOMIC ENERGY INSTALLATIONS

JANUARY 16-20, 1964

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I. Introduction

Mr. Moshe GILBOA, Ministry of Defense, and Professor Ephraim KATCHALSKI, Scientific Advisor to the Israeli Premier, welcomed the U.S. group cordially on Thursday evening, 16 January 1964. They proposed a tentative schedule for the visit which included the Weizmann Institute and the Nahal Soreq reactor site on Friday and which would provide a full day at the Dimona reactor facility on Saturday. The U.S. group emphasized our desire for an adequate visit to the Dimona site and accepted the proposed schedule provided that we would be able to begin a visit to this facility early Saturday morning. At the request of the U.S. group, Sunday visits to the uranium pilot plant at Haifa and to the Dead Sea area were added to the proposed schedule.

Throughout the entire visit, Israeli cordiality continued in a spirit of complete cooperation. The U.S. group spent over eleven hours at the Dimona facility on Saturday and, although it was clearly apparent that an extension of this part of the visit into Sunday would not be possible, the Israelis had assembled three or four dozen personnel at the site and made every effort to display the facility within that time limit. The visit continued after dark and some facilities without electricity were examined by flashlight. While time, and physical endurance, did not permit the examination of all parts of every building in this extensive facility, it is the consensus of the U.S. group that the conclusions reported below are a valid reflection of the capabilities of this facility as they exist at the present time.

II. Summary and Conclusions

1. The reactor went critical on 26 December 1963 but an extensive series of tests is planned and the approach to full power operation will not begin until late in 1964 (November-December). The fact that the reactor had gone critical did not significantly impair inspection.

2. The other major facilities of the center are complete or will be completed within approximately one year.

3. Construction of the fuel reprocessing pilot plant has been delayed indefinitely. This decision is the result of an increase of about 20% in the cost of the center over original cost estimates and of an arrangement with the French which has provided Israel with an initial amount of 150 grams of plutonium for experimental work. The concrete cell for the pilot plant does exist and is being used for storage. While there is no schedule for completing this plant there still is great interest and a good possibility that a fuel reprocessing pilot plant will be installed at some later date.

4. The center, currently estimated to cost approximately $60 million, is by far the most diversified and well-equipped nuclear development center in Africa and the Middle East. It probably represents the largest per capita investment in nuclear development facilities in the world.

5. Facilities now existing and others in initial start-up phases at Dimona, coupled with facilities committed for construction at Oran (or Oron), Israel (phosphate mines), will provide a capability for making 50 to 60 tons of natural uranium metal per year in 1½ to 2 years as a by-product of the phosphate operation This is 5 or 6 times the production rate which would be required for supporting th heavy water-moderated reactor if operated according to stated plans.

6. The reasons given for providing this capability for natural uranium production include the following: (a) desire to conserve essentially the full uranium production potential from phosphate operations, (b) desire to be self-sufficient, (c) represents minimum size equipment commercially available for one process step, and (d) their earlier belief that uranium will increase in value.

7. The fuel fabrication development facility will have the capability of fabricating a full core for the heavy water-moderated reactor in 2 to 3 months starting in about 1½ years.

8. The uranium concentrate pilot plant at Haifa is not a significant factor in production capability. Total production from the plant since about 1958 has been only a few tons (1 to 3) and current capability is only about 0.6 to 1.0 ton/year. It will be displaced by the new plant at Oran.

9. The reactor was found to be generally consistent with information previously available except that an intermediate coolant loop had been installed because of expected increases in chloride content of available cooling water. The actual fuel cartridges to be used in the reactor were inspected. The design power is 26 MW with an admitted capability for a 15 to 20% increase operating on only 2 of the primary coolant circuits. It was stated that all three coolant circuits could not be used simultaneously, a statement that may be true although it appears that relatively simple core and fuel element design modifications would permit operation at the full coolant capacity.

10. Present fuel stockpile includes one full charge (with a few spares) on hand, and approximately 10 tons (9 from foreign ores and one from domestic ore) in process. There is a possibility that the next core could be fabricated at Dimona; however, discussions are underway to obtain a second core from the French. It is expected that fuel definitely will be all of domestic origin starting with the third core.

11. Fuel now on hand from the French is subject to material control and is committed to be returned to the French.

12. It was stated that there is no choice at the present time regarding security controls on the site and activities related to it because of contractor concerns and commitments. However this position is to be reviewed when the plant is completed in a year or more and it is quite likely that the plant will be declassified. Some of the development work being done there currently is being reported in the literature with credits to the Israel Atomic Energy Commission but without specific reference to this site.

13. Discussion of the future prospects for nuclear power in Israel indicated that the relatively small size of plants [60 to 100 megawatts-electrical (MWe)] which could fit into the national grid during the next decade or so made power-onl reactors look economically unattractive. There is considerable interest in dual purpose nuclear plants for power and desalination of water. It appears that Mr. Mannes PRATT, Managing Director of the center, may accept our invitation to come to the U.S. to discuss this after the March 1964 International Atomic Energy Agency (IAEA) panel meeting.

14. Professor KATCHALSKI expressed interest (stated to be completely unofficial) in the possibility of undertaking cooperative research and development, or in other ways of obtaining some financial support (using counterpart funds, for example) for work at the center. In discussing the problems and possibilities of this, we noted that their stated plans to use the facilities for training programs for people from new African nations and other developing nations sounded particularly interesting. We expressed the opinion (also very unofficial) that some discussions with the IAEA along these lines might prove fruitful. Plans for future development programs are being worked out and it is likely that Mr. PRATT will be prepared to discuss them if he visits the U.S.

III. Recommendations

1. Further thought should be given to U.S. action to promote those uses of the training, research and development capabilities of the center (such as international cooperative programs) which would encourage complete declassification of the center and its operation of a training, research and developmen facility at the earliest possible time.

2. As long as the site remains classified, visits of the type just completed are desirable. From a technical view point, the next visit should be within one year. A visit sooner than this certainly could contribute to our knowledge of activities at the site and may be desirable for other reasons such as political factors. The recommended maximum interval of about one year is based on the following considerations: (a) by that time the reactor is expected to be at full power, (b) fuel material production facilities, although possibly not yet complete, may be more accurately assessed, and (c) the probability that their fuel production capacity is at a level inconsistent with the requirements of currently planned programs may be more accurately evaluated.

3. The next visit should include at least one person with background training and experience pertinent to detailed evaluation of the installations for recovery of uranium from phosphates.

4. The status of operation of the center in about 1 year will be such that it will be more important than ever that the arrangements for a visit permit more than one day at the site. A possible acceptable alternative would be to have two or more carefully coordinated groups reviewing different phases of the operation simultaneously. Also, a successful specialized visit in about 6 months may make it possible to limit the scope of the visit in one year so that it can be accommodated in one full day.

IV. Chronological Outline of the Visit

1. The U.S. team arrived at the Tel Aviv airport at 1730 on Thursday, 16 January 1964. As the three team members walked toward the airport reception area, they were met by Mr. Moshe GILBOA from the Israeli Ministry of Defense and conducted to a side entrance to the airport terminal. There, in a small side room, Professor Ephraim KATCHALSKI, Scientific Advisor to the Israeli Premier, welcomed the team on behalf of the Premier. He outlined a schedule for the visit which included the Weizmann Institute and the reactor at Nahal Soreq on Friday and proposed that the team spend Friday night at Beersheba so that their visit to the Dimona site could begin Saturday morning. He explained that this schedule was tentative and that he was prepared to change it to meet the desires of the U.S. visitors.

2. The U.S. team emphasized their desire to begin the visit to the Dimona site early Saturday morning and accepted the proposed schedule provided that a full day at Dimona would be possible. The team also requested a visit to the uranium processing plant at Haifa and to the Dead Sea area to see the expanding fertilizer production plant there. Professor KATCHALSKI agreed to arrange these visits on Sunday. He explained that there was no present uranium production in the Dead Sea area; this was only a proposal by the fertilizer company. At this point, it seemed appropriate to spend both Friday and Saturday nights at Beersheba.

3. Professor KATCHALSKI had arranged a dinner at his home on Thursday evening for the U.S. team and a group of physicists from the Weizmann Institute. He believed discussions with these scientists and the visit to the Weizmann Institute would prove interesting and would assist the evaluation of the

scientific competence of Israel. In response to a specific question whether these scientists knew the purpose of this visit to Israel, he replied that they did not. The scientists had been informed that the U.S. visitors were a scientific delegation visiting scientific installations in the area. The team should ask questions about the Dimona facility only of the personnel at Dimona.

4. The team was quartered in the Accadia Hotel, a resort hotel on the outskirts of Tel Aviv on the shore of the Mediterranean Sea. There were relatively few guests at this season. Mr. GILBOA had advised the team that Dr. WEBBER, U.S. Scientific Attache, desired to meet briefly with the members. Dr. WEBBER met with the team for 15 to 20 minutes for a discussion of the plans for the visit. He had been requested not to meet the team at the airport.

5. The guests at the dinner given by Professor and Mrs. Nina KATCHALSKI were: Mr. Moshe GILBOA, Escort Officer for the team; Professor Amos DE SHALIT, Chairman of the Physics Department at the Weizmann Institute; and Mrs. DE SHALI After dinner, the following scientists joint the group: Professor Benjamin GOLDRING, Head of the Van de Graaff group; Dr. Igor TALMI, theoretical nuclear physicist; Dr. H. J. LIPKIN, nuclear physicist; Dr. GILKAS (phonetic), mathematician; Dr. YEKUTELLI (phonetic), physicist; and Dr. Israel PELAH, in charge of the reactor at Nahal Soreq. The conversation was limited to technical topics of general interest and a discussion of some of the recent research at the Weizmann Institute.

6. On Friday morning, the team visited the Weizmann Institute as scheduled, spending most of the time at the Institute of Nuclear Physics with Professor DE SHALIT as guide. Professors KATCHALSKI, GOLDRING and GILKAS joined the group for lunch. In the afternoon, the team visited the reactor at Nahal Soreq, where Professor PELAH acted as guide. This 5 MW, American Machine and Foundry (reactor facility was closed on Friday afternoon and the team met none of the sit personnel. The program of this facility is unclassified, primarily training and research. It is open to fellows from other countries, and has some foreign stud sponsored by the IAEA. Literature on this installation was given to the team. Details of the visit and programs at the Weizmann Institute and at Nahal Soreq a included in this report in order to devote primary attention to the visit to the center near Dimona.

7. On Friday evening the team moved to Beersheba, where they were quartered in the Desert Inn, a new resort hotel on the outskirts of Beersheba. Mr. and Mrs. Mannes PRATT invited the team to their home for dinner. Present were: Professor and Mrs. KATCHALSKI, and Mr. and Mrs. RUTENBERG. Mr. RUTENBERG is in charge of Mechanical Engineering at the Dimona site. From late 1959 to late 1960, he attended the Oak Ridge School of Reactor Technology. During the discussions this evening, the team first learned that the reactor was already critical. No specific comment on this point was then, or subsequently, made by any member of the team. Conversations during the evening also gave first indications of Mr. PRATT's interest in water desalination, his opinions on nuclear power for Israel, and prospects for declassification of activities at Dimona.

8. The Escort Officer, Mr. GILBOA, who accompanied the team at all times during the visit, had by this time made arrangements for the remainder of the visit. He proposed that the team return to Tel Aviv Saturday evening, after the visit to the Dimona site, and fly by helicopter to the Haifa uranium pilot plant on Sunday morning. The team would then fly to the Dead Sea area Sunday afternoon and return to Tel Aviv Sunday evening.

9. The visit to the Dimona site was scheduled to begin at 0800, Saturday morning. Shortly before leaving the hotel to begin the 45 minute drive to the site, the team was advised that the road to the site was flooded and that it would be necessary to wait. The delay, however, was only 10 minutes, and the car was able to ford the flood without difficulty. Professor KATCHALSKI accompanied the team to the site and throughout the day. One of the members of the team, asked him prior to departure whether photographs would be permitted. He replied in the negative, explaining that it was feared that they would "somehow" fall into the hands of the Egyptians.

10. The team proceeded to the office of the site director, Mr. PRATT, for a one hour briefing on the site and its facilities. Present were: Mr. M. SIVRONI, in charge of site coordination, and Mr. D. RANEN, in charge of public relations. Both of these individuals, and Mr. PRATT, remained with the team during the entire visit.

11. A large map of the site was displayed on the wall. In response to a remark that the team would appreciate a copy of this map, Mr. PRATT explained that he would be unable to provide one. He suggested that, if a copy of the map were desired, the Israeli Atomic Energy Commission be approached by the U.S. Government. No objections were offered by anyone present when it became apparent that one member of the U.S. team was making a careful copy. In fact, with a laugh, Mr. SIVRONI commented on this and noted that true north was 37° off the line indicated as the site north.

12. Mr. PRATT explained that the reactor went critical on 26 December 1963 with part of the initial reactor load supplied with the reactor. The Israelis hoped to fabricate the second load themselves, although a second reactor load might be obtained from the same foreign source. He noted that the development firm required that Israel have a team of reactor operators responsible for the operation and that a five man team of operators had been trained on a Swiss reactor. This team had operated the Swiss reactor without any assistance from the Swiss.

13. The Israel electric power grid totals only 600 MWe. Mr. PRATT was now somewhat less optimistic for nuclear power for Israel since it would be difficult to insert large nuclear stations into the national grid, and smaller stations (60 to 100 MWe) were not economically competitive. Mr. PRATT expressed great interest in dual purpose nuclear power plants for production of electricity and desalination of water. Southern Israel needs water desperately and the larger capacity plants which such dual functions would justify might make nuclear power economically attractive in Israel at a much earlier date than would be the case otherwise. He represents Israel at the meetings in Vienna of the IAEA panel on desalination. He is thoroughly familiar with work in the U.S. on this subject including the Bechtel report. He is interested in coming to the U.S. after the March meeting of the IAEA panel to discuss this work. He was encouraged to do so.

14. The Israelis desire to produce their own reactor fuel to be ready for nuclear power although it is not obvious when it will be economic. They would nee a second reactor load for the Dimona reactor approximately at the end of 1965, if a went well. They expected to get 1000 megawatt days per ton (MWD/ton) and hoped to achieve 1200 MWD/ton. Israelis had visited the fuel element production plant operated by the fabricator and a cathodic welder has been ordered. There is in the n

(Haifa) a uranium pilot plant capable of producing approximately one ton of uranium per year from phosphate rock, and they plan to construct at Oran a uranium plant capable of producing 60 tons uranium per year from their phosphates which contain 1/10000 uranium. At the present time, they have obtained 20 tons of uranium concentrates from a foreign source.

15. In response to a direct question about the source of these concentrates, Mr. PRATT explained that the source was considered classified; adding that there are many facts about this site that are classified. These concentrates were in the chemical form of magnesium diuranate. Mr. PRATT said that it would be easy to guess the source, since only one country produced uranium concentrates in this chemical form. (Checks with the AEC Division of Raw Materials since returning have not confirmed that such material comes from a single source.)

16. The site includes a uranium metal plant with a nominal yearly capacity of 20 tons of uranium, which could process these concentrates to metal. They hoped to get about ten tons of uranium metal from the approximately 20 tons of concentrates previously mentioned. This would be adequate for a full reactor load. This quantity of uranium would be barely adequate to "break-in" their uranium metal plant. Interest was expressed in getting uranium concentrates from various sources in order to keep the plant busy until sufficient concentrates are available from the phosphate operations.

17. Mr. PRATT referred briefly to the problems caused by the Arab boycott. He explained that some foreign firms had severed connection with the project after their section of the work was completed. It was necessary now to maintain strict security practices. He hoped, however, that it would be possible to open the facility next year when the work was completed. The site included a hostel with a capacity for 40 people and students could be housed there. There is also a 24 room hotel on the site. It was stated that these housing facilities were due to their plans to use the plant for training - including people from other countries - such as the new African nations. In response to a question whether U.S. personnel could be permitted to work at the site under the present conditions, Mr. PRATT replied in the negative.

18. Under present regulations, no radioactive waste disposal to the ground was permitted. The water table was located at 80-90 meters with impenetrable

layers. However, there were faults in these layers and waste disposal had not yet been authorized. He hoped that disposal of some low-level waste would be permitted. It was stated that the reactor hazards committee in Israel was very severe at the present time and that construction might otherwise be as much as 30% cheaper.

19. The water treatment plant was designed to process water with up to 290 par per million (ppm) of chlorides. The chloride content of the present site water is 260 ppm and the plant has an excess capacity of approximately 25%. When the new wat supply from the Jordan River comes into service, site water will contain about 305 ppm chlorides. They expressed some concern whether the plant would be adequate for treatment of the higher chloride - content water.

20. All Israelis seemed surprised when one team member guessed that the site had cost about 160 to 170 million Israeli pounds. (3 Israeli pounds = 1 US dollar) Mr. PRATT replied that the cost would actually be somewhat greater than that figure The reactor had cost about 30% more than the estimate and the site as a whole had cost about 20% more than the estimate. It is concluded that the total cost will be about $60 million.

21. The site includes four water storage facilities. Three tanks of one million gallons capacity each are associated with the water treatment plant. One of these tanks was used for raw water and the other two for treated water. In addition, the site had a tall, cylindrical water tower of 500 cubic meters capacity.

22. The service facilities included a diesel electric power plant (3 diesels of 600 KWe each) for the site less the reactor, which has its own standby diesel power plant (3 diesels of 1000 KWe each). The service building distributes electricity to the site and supplies steam, and both industrial and dry compressed air. There are four steam boilers.

23. Electric power is supplied to the site from the national grid. Dimona and Oran were on the same line, although the reactor site has priority. The electric sub-station has two 15,000 kva transformers, one of which was a spare. The site actually uses about 8,770 kilowatts; 650 KW of which was supplied to the reactor by one of its own three diesel generators. (The reactor had three one megawatt diesel generators, one of which was always in service supplying about 650 KW to the reactor).

24. In about two months, the facility for handling plutonium is expected to be ready to begin work with the 150 grams of plutonium now on hand. By September, when the reactor would be operating at a higher power, they expected the hot laboratories to be ready to handle and to sample any burst fuel elements.

25. There is to be an underground emergency command post at the Medical Center. An emergency team of seven men is planned to always be on duty at the site, in addition to the regular operating crew. The reactor will operate on a 24 hour schedule.

26. The reactor is expected to be formally commissioned in January 1965. They plan to begin to increase power toward full power about October or November 1964. Foreign technicians would be present at the site until the reactor has been commissioned.

27. The site is surrounded by a single fence at a distance of about four kilometers to mark the exclusion area. There is also a triple fence around the immediate perimeter of the center which will be equipped with alarms as security against infiltration. The fence is not electrified.

28. After the briefing in Mr. PRATT's office the team was taken to a room opposite his secretary's office which contained a model of the over-all site and various schedule charts on individual buildings. (The model of the reactor viewed in the previous visit was said to be no longer available.) The following run down on status of major buildings was given:

a. The reactor went critical Sunday, 26 December 1963 at about 1530. The critical loading was 47 fuel elements each weighing 50 kilograms or a critical load of 2350 kilograms. Brown stains on the fuel elements after exposure in the heavy water caused some delay, but experiments have indicated no cause for concern. Reactor fuel elements will cool for "a year or so" in the storage pond.

b. Filtration - decontamination - reprocessing pilot plant. Filtration - began working in October 1963; Decontamination - not all equipment installed but will be ready when needed; Reprocessing pilot plant - postponed indefinitely.

c. Uranium pilot plant - is in initial phases of operation. First uranium may be produced in February. (See para. 47)

d. Waste disposal plant - now being tested. It will be comissioned by about September 1964.

e. Technology building (fuel fabrication) - scheduled to be commissioned by end of 1964. Expect to fabricate second core here although discussions also are being held with French regarding second core.

f. Site services - site electric power system has been commissioned. Standby diesel power will be completed by March, 1964.

g. Laundry - will be completed within about ½ month.

h. Hot laboratories - alpha-active facility will be completed about March 1, 1964. Hot cells in the metallurgical area will be completed by end of 1964.

i. Cold laboratories - commissioned and in operation for about one year or more.

29. Mr. NAOT acted as guide in the reactor building. He is in charge of the reactor. The team was also accompanied by Dr. PAZY, a reactor theorist, who was in charge of the theoretical group. Dr. PAZY had worked two years in France and had calculated the effects of vertical control rods in a reactor in which the fuel elements were horizontal. The reactor experimental facilities include: eight vertical channels in the graphite for isotope production, each capable of holding 20 sample units; two "rabbits"; a 2 x 2 meter thermal column; a biological irradiation facility 0.5 x 0.5 x 0.5 m.; 14 radial channels (6 for instruments); 4 tangential channels; one central channel 150 mm. in diameter; 20 experimental positions in the core for irradiations (located within the lattice positions) - each of these channels can handle 1 KW of heat generation. The radial channels may be cooled with a CO_2 gas system having a capacity of 8 kW or by a water system with a capacity of 20 kW. A 150 m. time-of-flight facility is also planned; to extend to the north of the reactor building.

30. Operating schedule calls for a one to one-and-a-half year irradiation of the first core to achieve 1000 to 1500 MWD/T. This cycle will begin in January 1965. It was stated that the first load must be returned to "our friends" who also require that each fuel unit be controlled; a long chart is used to record these control data. The reactor charge is a little more than 8 tons for 26 MW. There are 166 fuel elements, with five 10 kilogram slugs per element. Thermal flux is 5×10^{13} $n/cm^2 sec$ in the moderator at 26 MW. The fuel slug is 35.6 mm in diameter and about 50 cm long. The uranium contains 0.5% Mo. The surface has a helical thread with a pitch of about 5 mm and a height of about 1 mm. The aluminum can is pressure fitted with gas and is not bonded. The fuel is similar to that used in EL-3 except that it does not have a hollow center. The coolant tube has an ID = 48.6 mm and an OD = 51.6 mm.

31. There are 11 shim rods, 7 safety rods and two fine control rods. The cold, clean reactor has 8.4% excess reactivity; xenon and thermal effects are estimated to account for 3.4% of this excess reactivity. There are six control circuits; two linear with compensation, two linear without compensation and two logarithmic. The reactor will have an automatic start-up capability. The reactor reflector is about 110 cm thick, of which about 80 cm is graphite and 30 cm heavy water. The tank is 2.56 m in diameter. The core is 2.20 m in diameter. There are 166 fuel positions arranged hexagonally. There are also 20 control positions and 25 experimental positions located in the centers of fuel lattices and useable interchangeably. There are three positions for the measurement of water height.

32. Mention was made of plans to irradiate Thorium in the experimental positions in the core. It has been calculated that 250 kilograms of thorium may be irradiated in these channels for the production of U-233. This would use 4% excess reactivity and leave 1% excess reactivity for other purposes.

33. There is a burst slug detection system, a water temperature thermocouple and a water pressure monitor on each fuel position. An emergency fuel element cooling system will bleed water into each element from the top (reverse flow) which should be effective even if the reactor vessel is ruptured and the heavy water lost.

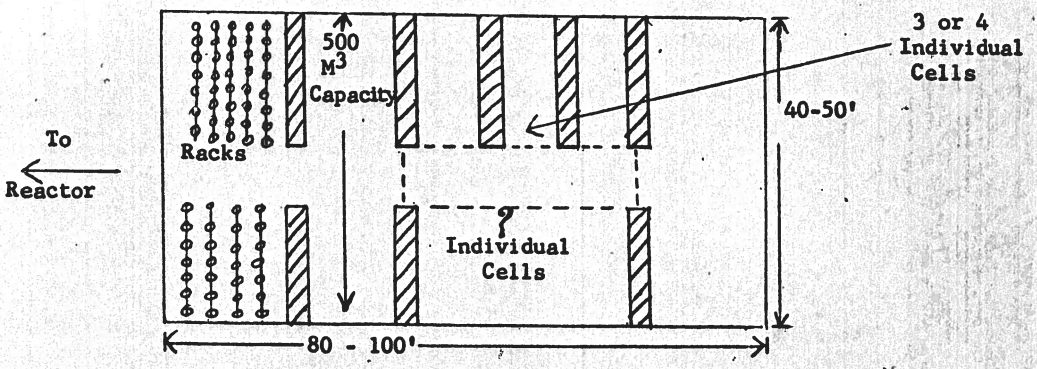
34. Reactor heat removal. The reactor has three loops in its primary coolant circuit. Each loop is designed for removal of about 13 MW with a coolant flow rate of 4.3 meters/sec on the fuel surface and a temperature rise of 12°C through the core. (inlet 46°C - outlet 58°C). The heavy water passes upward through the fuel element on a coolant pass and returns downward on a moderator pass. One of these three coolant loops is considered a spare. It was stated that the reactor power might be increased 15-20% using two loops but that it would not be feasible to operate all three loops at the same time because the pressure would lift up fuel elements. A comment from the team that design modifications could fix that led only to comments that the flow was already pretty high. At design power the maximum heat flux is 80 cal/cm^2/sec and the central fuel temperature is calculated to be 450°C.

35. In addition to the primary circuit of heavy water the reactor heat removal system includes an intermediate circuit of demineralized water and a raw water circuit to two cooling towers. The intermediate circuit was added when projections of chloride content in cooling water were increased. Each of of the three circuits has three pumps with the following ratings:

Primary - 900 cubic meters/hr per pump
Intermediate - 1400 cubic meters/hr per pump
Final - 1600 cubic meters/hr per pump

Each of the two cooling towers is conservatively designed by the Israelis for 15 MW at 25°C wet bulb temperature. The reactor shield is cooled with carbon dioxide gas with a maximum flow of 13,500 Kg/hr - normally the flow rate is 2/3 of this. The moderator blanket gas is helium.

36. The reactor fuel storage pond is quite extensive. Estimated dimensions: 40-50 feet wide, 80-100 feet long, depth 10 meters (given). There are two storage cells, side by side separated by a concrete wall with a water gate. The first cell is equipped with two racks each capable of holding one reactor fuel load. A passage from these first two cells runs past underwater examination and experimental facilities to a larger cell the full width of the pond which is to be used to store disassembled fuel elements which have cooled down somewhat. All in all, the storage pond is probably capable of holding about six complete reactor loads, plus some additional capacity were the experimental facilities converted to storag as well. The experimental facilities include disassembly equipment, equipment for the examination of fuel elements and slugs, and gamma irradiation areas. The following is a crude sketch of this facility.



37. The cold laboratories are divided into a chemistry laboratory area, an analytical chemistry area and a metallurgical area. Typical problems in the chemistry area were: electrochemical reduction of HNO_3 for waste disposal studies, studies of selective membranes for production of uranium from phosphoric acid, purification of heavy water, deuteration of ion exchange resins and studies of the corrosion of aluminum in heavy water. In the analytical chemistry area, equipment for infra-red analyses of heavy water and a Jarrell Ash mass spectrogra were noted. Personnel in these two chemical areas included Drs. LEVINE (phonetic) EPSTEIN (phonetic) and MULCANEY (phonetic).

38. Dr. BAR OR showed the metallurgical area. In this area are conducted studies of uranium oxides and nitrides, x-ray weld inspection, bonding methods, electroplating of nickel, uranium crystal grain growth, aluminum corrosion and pyrometallurgy. This facility has constructed a few uranium metal fuel slug samples, machined with the helical thread and pressure canned in aluminum. These samples were thermal cycled to destruction. A number of these test samples were displayed, probably totaling 50 to 60 kilograms of uranium. Dr. BAR OR displayed scientific publications being prepared for publication without an indication that Dimona was the site of the work. He plans a paper for the 1964 Geneva Conference. At this point in the visit, it became apparent that it would be impossible to complete the visit before darkness, and the already brisk tempo speeded up considerably.

39. The hot laboratory contains hot cells, a radiochemistry area, an analytical chemistry area, and an area suitable for the handling of dangerous alpha-active elements, such as plutonium. Mr. PALLAS and Mr. A. SERUSI were associated with this facility.

40. The hot cells are to be used for fuel element examination. There are three cells, each roughly 10 feet deep by 15 feet wide. These cells are capable of handling 10 kilocuries of activity but they are not gas tight. None of the experimental equipment was installed nor were the windows in place. The cells are individually roofed, although the roof slabs were not in place. The partition between two of the three cells could be removed. There is a conveyor running between the cells within the shielding. Small radioactive objects could

be brought by truck into a closed compartment at one end of the line of hot cells, removed and inserted into the first cell through a small hole (approximately a foot in diameter) in the side wall. Larger objects could be inserted into the cells by removing the ceiling shielding slabs. The hot cell area was equipped with cranes suitable for this purpose. The hot cell areas are well compartmented to prevent the spread of radioactivity and are associated with changing and wash-up areas for personnel. Completion of this facility is estimated for the end of 1964.

41. In addition to the three major hot cells there is a large room with a half dozen or more cells built of lead brick for handling material with lesser amounts of acitvity.

42. The radiochemical area of the hot laboratory contained equipment for the preparation of radioisotopes, for the "tagging" of compounds with radioactive atoms, conventional radiochemistry, and a gamma (c.) cell. Two rooms were equipped with lead cells for radioisotope production and two rooms contained glove boxes for the radiochemistry.

43. Analytical chemistry in the hot laboratory included spectroscopy, alpha, beta, gamma measurement, sample preparation and gas chromatography. This was one of the fastest trips in the visit.

44. The facilities in the hot laboratory for the handling of dangerous alpha-active substances -- plutonium, for example -- was very well equipped with glove boxes containing a wide variety of equipment. This facility was compartmented from the rest of the building with its own change and clean-up areas. The filters serving its ventilation system were separate from the ventilation system for the rest of the building. Among the equipment noted were: arc furnaces, conventional furnaces, x-ray equipment, chemical facilities, heat treatment and metallurgical equipment. Experiments will be performed with plutonium from the 150 gram quantity now available. Apparently the amount in use in any room at one time will be limited to 20 grams. Mr. PRATT commented that the plutonium was in his custody. Scheduled start of operations in March 1964 seems reasonable on the basis of the current status.

45. Mr. SNEEDORF (phonetic) was associated with the waste disposal facility. This facility will handle all of the radioactive waste generated at the Dimona site -- and waste from other parts of Israel as well. Since waste disposal to the ground or the atmosphere is prohibited at present, all waste must be concentrated and stored. The facility can handle "some hundreds of curies". It can treat 500 to 1000 cubic meters/month containing up to 1 milli-curie/liter. It uses evaporation and precipitation for concentration of the waste. In two steps, the waste are concentrated from 10% solids to 40% solids. There are a total of five storage tanks. Two buried tanks each of 500 cubic meters capacity are located on the south side and close to the building. These tanks are capable of holding the water from one compartment of the fuel element storage pond should it become contaminated through a fuel element rupture. In such a case it would be necessary to dump the contents of that cell into one of these 500 cubic meter tanks. Three other buried tanks, located to the north of the building have a capacity of 800 cubic meters each.

46. The decontamination and filtration facilities are located in a large building to the west of, and adjacent to, the reactor building. This facility supplies ventilation to the reactor building, the waste disposal building, part of the hot laboratories, and the uranium metal production plant. (Team not certain of this building.) The air returning from these facilities is filtered with absolut filters before release to the atmosphere. The building also contains extensive facilities for the decontamination of equipment. This facility is capable of handling items approximately some 5 x 10 feet in size and is equipped with cranes with capacities around 10 to 15 tons. Decontamination will be carried out by personnel, not be remote control, although there is a glassed in observation point at one corner of the room. This area is equipped with change and clean-up areas for the personnel. The building houses the meteorological facilities, but these were not visited. The building also is the site of the radiochemical fuel reprocessing pilot plant which was to have a capacity of one kilogram of uranium per day. The team was advised that this facility had not been constructed and that there were no present plans for its construction. The cell for this pilot plant does exist; however, the space is being used for storage. This cell was

shown to the team -- as a space behind steel doors some 15 feet high. The space behind the doors was completely filled with boxed and crated equipment, so far as it was possible to see.

47. The uranium metal production plant is capable of processing uranium concentrates to uranium metal in the form of 80 kilogram ingot. The wet processes, dissolution and raffination, are followed by dry processes, conversion of the uranyl nitrates to UO_3, to UO_2 and to UF_4. The latter is reduced to uranium metal with calcium. Nuclear grade uranyl nitrate is produced in pulsed columns using TBI They hope to produce the first ingot in July.

48. The uranium metal production plant now has a load in process. This load, stated to be 9½ tons of nuclear grade uranyl nitrate at this stage of its processing, resulted from the processing of the 20 tons of uranium concentrates (as magnesium diuranate from foreign sources and a "small" quantity of UF_4 from phosphate rock from domestic sources produced by the uranium pilot plant at Haifa. An attempt to elicit the total domestic production of UF_4 resulted in considerable confusion. Dr. J. LAVI, the chemical engineer in charge of the plant, spoke rathe halting English. Under cross examination by two members of the US team, he gave the design capacity of the Haifa pilot plant as 3 tons of uranium per year and stated that it was built in 1958. The implication that some 15 tons of uranium fr domestic sources might now be available seemed to agitate Mr. PRATT, the site director, and he joined in the cross examination. During a rather confused discussion, it developed that Mr. PRATT disagreed that the Haifa pilot plant ever had the capability of producing 3 tons uranium per year. He admitted that Mr. LAVI ha designed the plant but attempted to get him to admit that the actual production capability was much lower. Mr. LAVI pleaded ignorance of the actual production capability since he was no longer associated with the facility but finally used a figure of about 3 tons as the total production from the plant. Mr. PRATT, rather dramatically, stated that he had on his desk a letter from the fertilizer firm which offered to supply 1½ tons of uranium (presumably per year) and he expressed doubt that they could do it. Further discussion revealed that production of uraniu from the phosphates contaminates the product phosphates with a smell that makes them unsuitable as cattle feed. Thus, the uranium pilot plant must be shut down whenever phosphates for cattle feed are produced. NOTE: The figure of 9½ tons

uranium as uranyl nitrate presently in process from both foreign and domestic sources was given subsequent to this discussion and after an opportunity for consultation. It was, of course, impossible to verify this figure since the tanks displayed were large in volume; the calibration of content indicators was unknown and the uranium concentration in the solutions was known only from Israeli statements (50-60 gm U/liter in the technical grade uranyl nitrate from the first stage processing).

49. The plant is now operated on a batch basis with one crew, moving from process to process. It requires 145 days to process a batch containing approximately ten tons of uranium to the metal, thus the "batch" process capability of the plant is about 20 tons of uranium metal per year. This process proceeds as follows: It requires 40 days of one-shift per day operation with the crew to convert ten ton of contained uranium to technical grade uranyl nitrate and 40 additional days of continuous operation to process the batch to nuclear grade uranyl nitrate (3 ppm silicon and 0.3 ppm boron) in the next section of the plant. Forty more days of one-shift operation are required to convert the uranyl nitrate through the oxides to uranium tetrafluoride. A final 25 days is required to reduce this same ten tons of uranium from the UF_4 to the metal in one-shift batch processing.

50. The maximum capacity of this plant, if operated on a continuous basis, is about 50 to 60 tons of uranium metal per year. The design size of this plant was determined by the capacity of the smallest commercially available furnace for the production of UF_4. Name plate data from this furnace is given below:

Manufacturer:	RIPOCHE
Address:	8 Rue Ferris
	Paris 14
Type:	XCC 60
Power:	15 KW

It was stated that the specification of this furnace identifies it as the "L 100". Three of these furnaces were installed. One as a spare, one for the production of UO_2, and a third for the conversion of UO_3 and UO_2 to UF_4. It was understood that the latter furnace was in the production chain -- that the production of UO_2 was used as part of the feed to the UF_4 furnace to insure complete conversion to UF_4. A second reason for the selection of 50 tons of uranium metal per year as the maximum capacity of this plant was stated to be the desire to match the anticipated production of uranium from the Oran phosphates which were estimated to be capable of yielding 50-60 tons of uranium per year when the expanded phosphate plant at Oran is complete.

51. The technology building which is intended for fuel fabrication (development and production)was without electricity. It was now about 1900 and dark. These facilities were examined in the dark with the aid of a few flashlights and not all of the building was visited. Flexible partitions had been erected and a considerable quantity of equipment was in place, but most of it not yet firmly mounted. The facility has two crucible units for an induction furnace, each capable of handling the 80 kilogram ingots produced by the uranium metal plant. Among the items of equipment observed during this flashlight inspection were: two uranium lathes, two heat treatment furnaces, uranium surface treatment equipment, and two vacuum furnaces. All equipment observed was new and apparently of excellent quality. In response to a question, the Israeli in charge of the shops estimated that it would require about 1½ years to acquire the knowhow, then the facility would be capable of producing the fuel elements required for a full reactor load (approximately 8 tons) in two to three months, i.e. a yearly production capability of about 40 to 50 tons of completed uranium fuel elements. The status of the facility is consistent with the schedule to be in commission by the end of 1964. Therefore, if all goes well, it is quite possible that the second core for the reactor could be fabricated there.

52. The team now returned to a part of the cold laboratory building which had been omitted earlier in the day. The facility was the radiochemical separation process development area, and included small scale experiments testing processes an equipment with cold chemistry techniques. One of the items under development was a small mixer-settler unit about 8" to one foot wide by 1-1½ feet long and one foot high which was stated to be capable of processing some 500 grams of uranium per day The Israeli displaying this equipment seemed somewhat surprised when asked what the rather large area (about 50' x 50' with a 20 foot ceiling) would be used for now that the radiochemical fuel reprocessing pilot plant would not be constructed. It appears that the decision not to construct this facility may not be widely known in the site, as yet, and that the development of separations processes and equipment will continue. A glass shop and an area for training operators of remote manipulators for the hot cells were also part of this building, but were not visited.

53. At this point, the visit to the Dimona site terminated in a brief farewell gathering in Mr. PRATT's office. All present were tired, but still cordial. The day had been cold and rainy, the facilities covered extensive and spread over an area about 1/2 x 1/3 miles. It is worth noting that Professor KATCHALSKI, Scientific Advisor to the Premier, and Mr. PRATT, the Site Director, had accompanied the team all through the day. All facilities requested were displayed and at no time was there any evidence of an attempt to interfere with or to influence the activities of the team. The Dimona reactor site is an extensive facility. All buildings and all parts of every building were not visited. Within the limiation that the visit be completed on Saturday, a restriction made clear by Mr. PRATT late in the day when he indicated that an extension of the visit into Sunday would not be possible, this visit was as comprehensive and thorough as the time permitted. Among the facilities not entered were: warehouse and garage buildings (about 10, some not complete), the medical center (incomplete), the laundry (complete), the service building (apparently complete) and the hostel (complete - containing theoretical physics section and a small computer). It is probable that a significant fraction of the technological building was not visited (no electricity but no reason to believe that the part seen was not representative).

54. Professor KATCHALSKI confirmed, in response to a question, that the Dimona site is under the Israeli AEC. Professor BERGMAN is chairman of a committee to develop a research program for the reactor and associated facilities.

55. By the time the visit to Dimona was finished, it was too late to proceed to Tel Aviv directly, and the entertainment arrangements made by the Israelis had to be cancelled. The team dined with Mr. PRATT, Professor KATCHALSKI and Mr. GILBOA in Beersheba and returned to Tel Aviv well after midnight. In the hotel elevator, they were joined by Dr. WEBBER, the U.S. Scientific Attache, who desired to report progress to Washington. A brief description of the events of the day was delivered to Dr. WEBBER, mostly in whispers in a corner of the room. He had been kept informed of progress during the day and already knew approximately when the team left the site.

56. On Sunday morning, the team met Mr. GILBOA and proceeded to the Tel Aviv airport where a military helicopter with a crew of four waited to convey them to Haifa. At the offices of Fertilizers and Chemicals, Ltd. the team met Mr. A. GOLDBE

the Managing Director of the plant. Mr. GOLDBERG, a chemical engineer trained in England, had started this plant in 1947. He reviewed the history of the potash plants in Israel near the Dead Sea and the mining of phosphate ores near Oran. The latter deposit, selected for exploitation by them even though it is not the best, has yielded two million tons of phosphate rock since 1952. The phosphate mines ship approximately 80,000 tons of phosphate rock per year to his fertilizer plant at Haifa. This is processed to produce single super phosphate, gypsum, triple super phosphate, sodium tripolysulphate, and dicalcium phosphate. The uranium pilot plant was constructed by the Israeli AEC. It is now rented for one Israeli pound per year by the chemical fertilizer plant. The chemical works now uses about one-half of the building for the production of industrial chemicals. The uranium pilot plant may be operated only when the phosphates are being processed for purposes other than cattle feed. The solvent extraction used for the recovery of uranium contaminates the phosphate product with traces of butanol. The smell is barely perceptible to a human with a good nose, but the cattle refuse to eat it. The uranium produced is sold to the Israeli AEC. The plant has a maximum capacity of about one ton uranium per year. Its actual production is about 600 kilograms per year. Its total production was stated by Mr. GOLDBERG to have been about one ton of uranium. The uranium production is not a particularly profitable process. Phosporic acid production is reduced. Mr. GOLDBERG stated that he would like to get 100,000 Israeli pounds per ton of the UF_4 produced, but was unable to get that much. The UF_4 technical grade produced by the plant costs about 80 Israeli pounds per kilogram, without considering the depreciation of the plant. If a larger and more efficient plant were engineered, he stated that he could produce UF_4 at about 60 Israeli pounds per kilogram. There would not be much reduction in cost because it was a tank-type operation with greater production achieved by increasing the number of tanks.

57. The team visited the uranium pilot plant. It occupied about half of a building approximately 80 x 160 feet. This building was the only building observed on the site of the extensive chemical production plant for which any security measures were evident. The uranium pilot plant building had a fence on which a sign indicated, in English, "No Entry without Authorization". The fence, and the sign, however, were several years old. The fence was incomplete on one side of the building. It was evident that this security measure was not

currently in force. The pilot plant equipment was small, old and corroded. The solvent exchange tank was only about 4 feet wide, 4 feet high and about 8 feet long. No UF_4 was evident. Mr. GOLDBERG questioned a worker in the building and stated that the plant had not been operated for the last eight weeks because an urgent foreign order for phosphates was being processed.

58. Mr. GOLDBERG was asked whether the problem of odor was being studied. He replied that two men had worked on the problem for the last year without any evidence of success.

59. The team then proceeded to Sedom on the Dead Sea to visit the expanding potash plant there. It was established that this facility is not associated with the production of uranium in Israel and that the phosphate rock deposits in this vicinity are not processed at this location. Phosphate rock is mined at the present time near Oran, which will be the site of the uranium concentrate production plant with a capacity of 50-60 tons uranium per year as UF_4.

60. At a farewell dinner with Mr. GILBOA and Professor KATCHALSKI, the team discussed several further points of interest. The phosphate mines at Oran are being increased by about an order of magnitude, i.e. to about 800,000 tons per year. The decision to build a uranium plant at Oran is firm and it will be about 1½ years before the plant will be completed. He did not think construction had started but the schedule seems consistent with a statement by Mr. PRATT to one member of the team that ground was broken for the plant on the day of the visit to Dimona. This large production of uranium, 50-60 tons per year was rationalized by Professor KATCHALSKI on the grounds that Israel wanted to be self-sufficient with their own uranium, and because they expected uranium to become increasingly valuable. He left the impression that the actual level of production is subject to future decisions.

61 With respect to the decision not to construct the radiochemical separations pilot plant at this time, Professor KATCHALSKI explained this decision as the result of the increased cost of the Dimona site and because the French had supplied 150 grams of plutonium for experimental purposes. They had promised additional small quantities. Professor KATCHALSKI hopes that the plant will be built in a year or two because it would be valuable to train personnel.

62. Professor KATCHALSKI then inquired "informally" about the possibility of joint R&D projects between the U.S. and Israel which could help finance the Dimona research program. No commitment was made by the U.S. side, but it was noted that joint projects would be facilitated if the site were opened up. It was stated that this was understood and would not be a problem. The situation regarding security at the site is expected to be reviewed again when construction is completed and when assisting foreign technicians leave - in a year or so. The possible role of the IAEA in assisting development of joint projects and in the training of students from other countries was discussed. It was suggested that Mr. PRATT might be prepared to offer some suggestions when he visits the U.S.

63. The team departed at 0930, Monday, 20 January 1964. Departure followed the same procedure as arrival, with the team waiting in the small room at the side of the terminal building until the aircraft had been loaded. Arrival and departure cards, passports and baggage arrangements were made by the Israelis.

V. Personnel Met by the Team

Moshe GILBOA - Escort Officer

Professor Ephraim KATCHALSKI (Hebrew-KACIR) - Scientific Advisor to Israeli Premier

Mrs. Nina KATCHALSKI - Wife of Professor KATCHALSKI

Professor Amos DE SHALIT - Chairman, Department of Physics, Weizmann Institute

Professor Benjamin GOLDRING - Head, Van de Graaff group, Weizmann Institute

Dr. Igor TALMI - Theoretical nuclear physicist, Weizmann Institute

Dr. H. J. LIPKIN - Nuclear physicist, Weizmann Institute

Dr. GILKAS (phonetic) - Mathematician, Weizmann Institute

Dr. YEKUTELLI (phonetic)- Physicist, Weizmann Institute

Mrs. DE SHALIT - Wife of Professor DE SHALIT

Dr. Israel PELAH - Head of reactor at Nahal Soreq

Mr. Mannes PRATT,- Director of the Dimona Site

Mrs. PRATT - Wife of Mr. PRATT

Mr. RUTENBERG - Mechanical Engineer at the Dimona Site

Mrs. RUTENBERG - Wife of Mr. RUTENBERG

Mr. M. SIVRONI- In charge of "coordination" at Dimona

Mr. Y. NAOT - In charge of the Dimona reactor

Dr. A. PAZY - Theoretical reactor physicist, in charge of theoretical group at Dimona

Mr. LEVINE (phonetic) - Cold Laboratory

Mr. EPSTEIN (phonetic) - Cold Laboratory

Mr. MULCANEY (phonetic) - Cold Laboratory

Dr. BAR OR - Metallurgist, in charge of cold metallurgy

Mr. PALLAS - Hot Laboratory

Mr. A SERUSI - Hot Laboratory

Mr. SNEEDORF - Waste Disposal

Dr. J. LAVI - Uranium metal plant

Mr. A. GOLDBERG - Managing Director of Fertilizers and Chemicals, Ltd. at Ha

Mr. AMIR - probably associated with the Dimona reactor

Mr. ADZARI (phonetic) - probably associated with the alpha-active section of the hot laboratories

Mr. D. RANEN - Public relations at Dimona

Mr. R. GVION

Mr. R. TIBERGER

VI. General Comments on the Visit

1. The usual size of the visiting group was eight people plus the scientist actually connected with the facility being visited. This group included the thre team members, the site director, the scientific advisor to the premier, the indivi dual in charge of site coordination, the public relations man, and the escort officer. Two or three additional scientists were present at each facility. It is apparent that this assembly was somewhat unwieldy in the narrow corridors and stairways of a typical nuclear facility. There are both advantages, and dis- advantages to this situation from the viewpoint of efficient inspection. Were there only one inspector, it is probable that the escort group would have remaine the same -- thus the inspector is dominated by the inspected and has little freec to observe and to ask questions of (possibly) independent sources. In the preser instance, three U.S. personnel were probably ideal. Not too many to prevent the observation by each individual of the specific facility or item being displayed, yet large enough so that independent but essentially the same questions could be asked of different site personnel without appearing to be unpleasantly repetitive

2. The Dimona site is not yet in full operation. Thus, this one day visit was adequate to establish the principal features of the site. Subsequent visits will require more time, and perhaps, personnel with different scientific interes A single team of three individuals, probably the optimum size for a single group will require at least two days to cover the site. Even in two full days, it mus

not be assumed that a team of three visitors without police powers would be capable of detecting skillfully concealed facilities. The scientific competence of the team should cover the full range: mining of phosphate rock, recovery of uranium, production of uranium metal, fabrication of fuel elements, reactor operatio and research, chemical processing, and plutonium metal production and fabrication. If Israeli political sensitivity remains high at the time of the next visit, and only Saturday is available, it is probably desirable to accept this situation without question and request two successive Saturdays with the team leaving the country in the interim. This schedule has the advantage that the team will be able to discuss freely the observations made and plan the second stage of the visit without interference from social obligations.

3. If only one day is available, then two or more carefully coordinated two or three man teams might be able to cover the site effectively. The teams would be composed according to the scientific disciplines required to examine a group of specific facilities. This technique has a number of disadvantages from both the Israeli and U.S. viewpoints. From the Israeli viewpoint, such a visit is probably intrusive and offensive. It would no longer be possible to conceal from their own personnel (should they so desire) that this is an "inspection" not a "visit". From the U.S. viewpoint, unless such an inspection were carefully coordinated in advance with detailed briefings and objectives, even such an intrusive technique would not prove that the facility was being used only for peaceful purposes. It would be possible for the hosts to play each team against the other, were the teams not well briefed and firm in their intent, and thus conceal or misrepresent areas within the facility.

4. Should the evaluation of the data presented in this report or other information obtained subsequently establish the requirement for a future inspection with even greater access, it would probably be desirable to have present, at the initial planning sessions between the U.S. team and the Israelis, the senior U.S. official in Israel most directly associated with the negotiations leading to such a visit. This official could present to the group the precise terms of the agreement and the U.S. understanding of the conditions of the visit. When the negotiators are separated from the visitors, it would probably be difficult to achieve the maximum degree of access should the Israelis have agreed only reluctantly to accept the more intrusive visit.